Latest design of compact hot strip mill from SMS Siemag

On 15 June 2010, the new 330m long compact hot strip mill of Çolakoğlu Metalurji AS, Turkey, produced its first coil. Thanks to the complete supply of all mechanical, electrical and automation equipment by SMS Siemag, the mill was quickly run up and producing excellent strip quality right from the start.

Çolakoğlu Metalurji is a Turkish family-run business which, over the past few decades, has turned from steel trader into steel producer and, following commissioning of its hot strip mill in 2010, has changed its product portfolio from long products to high quality hot strip. Annual production is 3.0Mt of carbon, HSLA, tubes, dual-phase and TRIP steel grades.

The hot strip mill (see Figure 1) was built in a building previously operated as a wire rod and section mill, thus it had to be of compact design. The main components are a reversing roughing stand with edger, a mandrel-less coil box, a seven-stand finishing mill, laminar cooling system and a pallet conveyor system. Thanks to the coil box, the distance between the reheating furnace and the coilers is only 300m.

The mill was also built on stilts in order to avoid ground water problems that may arise from the sea nearby. This has the advantage that the supply systems located under the rolling mill, such as those for hydraulic oil and pressure water, are accessible from floor level. The foundations are designed as a continuous block, preventing settling of individual mill areas and hence disturbances in the rolling process.

The basic mill technical data are:

**Slabs**
- Thickness: 180-250mm
- Width: 800-1,650mm
- Length: max. 12,000mm
- Weight: max. 39.0t

**Finished strip**
- Thickness: 1.2-25.4 mm
- Width: 9,800-1,650 mm

**Coils**
- Outside diameter: max. 2,200mm
- Specific coil weight: max. 24.0 kg/mm
- Weight: 39t

**ELECTRICAL AND AUTOMATION**

The mill operates on SMS Siemag’s X-Pact® electrical and automation system. The scope of supply included the Level 1 and Level 2 systems with process models, technological measuring systems, instrumentation, sensors, a common HMI for both automation levels and all drive systems with...
their converters and all motors. Of critical importance for product quality are the technological process models: pass schedule calculation (PSC), profile, contour and flatness control (PCFC) and the cooling model, Cooling Section Control (CSC). These are based on mathematical-physical models that take into account parameters which influence the rolling process and material properties.

**MANUFACTURE AND COMMISSIONING**

With overall responsibility for mechanical, electrical and automation equipment, SMS Siemag was able to use a well-conceived, proven component design, manufacture with maximum quality standards, use advance testing of the mechanical equipment and automation system and tune all systems to each other. The result was trouble-free commissioning, fast production run-up and good mill performance.

The core components such as the mill stands, gear units and drive spindles, coiler and hydraulic adjusting systems, were all fabricated in SMS Siemag’s workshop which includes more than 70 state-of-the-art machine tools.

The automation system was tested before delivery using the tried-and-tested Plug & Work method, ie, after the automation system has been set up at the test field, Plug & Work simulates the production process and allows the automation functions to be tested and optimised under realistic conditions before installation at the customer’s works. With the help of the simulation system, operators were able to control production virtually, thereby becoming familiar with the functions of the mill and its handling in realistic operating situations, thus contributing to a significantly shorter commissioning period.

**ROUGHING MILL**

The production process starts by heating the slabs to rolling temperature in the walking beam furnace. A high-pressure descaler, operating at a maximum pressure of 200 bar, then removes the scale that has formed during heating. The four-high reversing roughing stand (see Figure 2) rolls the slab down to the transfer bar thickness in five to seven passes as calculated by the pass-schedule model. The stand has hydraulic roll-gap adjustment systems and a maximum roll force of 45MN.

The transfer bar width is preset by means of the edger at the entry side. With the help of a special control of the edging pass (short stroke) at the head and tail ends, the transfer bar geometry is optimised so that cropping losses are reduced.

To avoid transfer bar camber as a result of thickness and temperature rundowns in the slab, camber-free rolling is used, based on the interaction of the automatic roll alignment control (RAC) and the heavy, position-controlled side guards in the entry and exit section of the stand. The side guards...
actively counteract the formation of strip camber. RAC keeps the roll gap in the roughing stand perfectly parallel as well, in the case of slabs with temperature or thickness rundown, thus enforcing in the transfer bar a mass flow transverse to the rolling direction. This eliminates wedges and the formation of transfer bar camber.

**Technical data:**

**Edger**
- Roll diameter: 1,100-1,000mm
- Edging force: max. 6,700kN
- Width reduction: max. 100mm
- Opening dimension 700-1,850mm
- Main drive: 2 x 1.500kW
- Nominal torque at the rolls: 462kNm

**Four-high reversing roughing stand**
- Work roll diameter: 1,250-1,125mm
- Backup roll diameter: 1,500-1,350mm
- Barrel length: 1,850mm
- Rolling force: 45,000kN
- Bearing assembly: type KLX Morgoil bearings
- Main drive motors: Twin-drive, rated power: 2 x 7,500kW, rated torque: 1432.5kNm
- Hydraulic adjustment systems
- Morgoil® bearings, series KLX®
- Sieflex® spade-end spindles

**Mandrel-less coil box and crop shear**

It was the mandrel-less coil box between the roughing and finishing mill that made possible the particularly compact layout of the mill. The coil box serves to coil the transfer bar after the last pass and then uncoil it during finish-rolling. By temporarily storing the rolled stock in the coil box, temperature homogenisation is attained so the strip enters the finishing mill at almost constant temperature, allowing a stable rolling process.

The coil is transferred without a mandrel from the coiling to the uncoiling station and so avoids undercooling of the inner wraps. Additionally, patented, width-adjustable heat insulation hoods reduce the thermal radiation of the coiled transfer bar.

Before entering the finishing mill, the drum shear crops the head and tail end of the strip using a separate pair of knives, thus giving the head and tail end of the transfer bar the shape needed for reliable threading and unthreading.

An automatic optimisation system consisting of a strip-shape detection unit and speed measuring system reduces the crop lengths (see Figure 3).

**Technical data:**

**Mandrel-less coil box**
- Transfer bar thickness: 25-40mm

**Drum-type crop shear**
- Strip cross section: max. 50 x 1,650mm
- Shear force: max. 13,000kN
- Transfer bar speed during cutting: 0.5-2.0m/s
- Two shear knives per drum, offset by 180°

**Finishing mill**

The seven-stand finishing mill rolls the transfer bar to the required final thickness of between 1.2 and 25.4mm. Before this, the secondary descaler removes the scale that has formed during roughing. All stands are equipped with hydraulic adjusters for thickness control. The strip profile, flatness and contour are set in the finishing mill by the CVC® Plus system in combination with the work roll bending system. Using the roll force, elastic deformation, thermal crown, wear of the work rolls and further parameters, the relating technological process model PCFC calculates for each strip the correct shifting position for the work rolls equipped with the special CVC® Plus roll barrel finish, as well as the setting values for work roll bending. In this way the roll gap for each strip is adjusted to the changing conditions.
Thanks to CVC® Plus, stands F1 to F4 and F5 to F7 each operate with the same roll barrel finish. This reduces the number of sets required and reduces roll workshop time. Work rolls are changed fully automatically in a few minutes, and a roll changing car transports the work rolls back and forth between the roll bay and roll workshop.

The hydraulic loopers between the stands ensure stable strip travel. The anti-peeling device in stands F1 to F4 reduces the surface temperature of the strip and thus the thermal load of the work rolls by spraying water immediately in front of the roll gap. This slows down the growth of the oxide layer on the rolls and increases roll life. The roll gap lubrication system in stands F2 to F6 reduces the friction in the roll gap by spraying an oil-water mixture on the work rolls, thus reducing the forces and amount of work needed.

The finishing stands are characterised by their compact and low-maintenance design. This ensures that each hydraulic actuator is controlled by its own module. The individual modules are combined on the millstand platform to form compact columns. There they are protected, yet easily accessible for maintenance purposes. The pipes between the control modules and the actuators run along the side walls of the finishing stands, which provides optimal protection from damage. All equipment arranged below the mill floor and services for the supply of the millstands with hydraulic oil, water or electricity are also optimised for easy maintenance.

The finishing stands are powered by three-phase AC motors with a rating of 8,000kW. The drive power is transmitted in stands F1 to F4 via main gear units, mill pinion gears and Sieflex®-spade-end spindles. Stands F5 to F7 do not have a speed reducer stage. The gear units are equipped with case-hardened gearwheels and teeth to ensure the transmission of extremely high drive torques. The drive spindles are lubricated by an integrated oil recirculation system, which optimally protects the spindles from damage. Figure 4 shows the roughing and finishing mill control pulpit.

Additional technical data of seven-stand finishing mill
- Rolling force: F1 to F4: 42,000kN; F5 to F7: 36,000kN
- Work rolls: Barrel length: 1,850mm, diameter F1 to F4: 820/720mm, diameter F5 to F7: 700/630mm
- Backup rolls: Barrel length: 1,850mm, diameter F1 to F7: 1,500/1,350mm
- Bearing assembly: Morgoil bearings

**STRIP COOLING SYSTEM**
The strip cooling system uses selective cooling to produce the material properties of the rolled stock. Intelligent cooling strategies make it possible to produce a wide variety
of steel grades with cost-effective alloying concepts.

The laminar cooling section is 80m long and divided into 17 individually controlled groups (see Figure 5). The last two groups are called trimming zones in which, using precise control of water, it is possible to attain the required coiling temperature. Water flow is typically 12,700 Nm/h.

The optimal cooling strategy for each strip is preset by the X-Pact® cooling model to calculate the relevant cooling curve. This is based on the implementation of essential physical operations such as the thermal conductivity in the strip thickness direction, heat transfer in air and water zones, as well as the transformation behaviour of the material during the cooling process.

The upper cooling headers of the laminar cooling system can be swivelled through 90 degrees, thus making the roller table accessible for maintenance by crane. The rollers form a unit with the motor and, being designed as quick-change units, can be replaced within a very short time.

COILERS AND COIL CONVEYOR SYSTEM
At the end of the hot strip mill, two fully hydraulic down coilers coil the rolled strip. These have been optimised for straight-sided, closely wound coils of all steel grades and dimensions, as well as reliable coiling and quick discharging (see Figure 6).

The incoming strip is picked up by the pinch roll unit and reliably routed in the entry gate to the coiler mandrel. Throughout the coiling process, hydraulic side guards centre the strip and thus ensure straight-sided wound coils. While the first few wraps are wound, the three wrapper rolls of the coiler are lifted off the strip surface for a short moment before coiling round the strip head end. This automatic step control system prevents marks on the inner wraps and protects the coiler mechanical equipment.

The wound coils are transferred to the pallet-type conveyor system and taken to the coil store with a horizontal coil axis. Coil temperature is 700°C maximum and throughput is 60 coils per hour. Coil outside diameter is 1,160-2,150mm and mandrel diameter is 762mm (expanded).

The novel conveyor system is characterised by a safe and gentle transport of the coils with low investment, maintenance and operating costs. With the pallets controlled individually, operations in the coil store are uncoupled from production in the hot strip mill. This allows, for example, the formation of buffers and thus the optimal utilisation of the shop crane. Empty pallets are returned in parallel with the loaded pallets.

COMMISSIONING AND RESULTS
On 15 June 2010, the first strip was produced two weeks ahead of schedule. From day 1, two coilers were used for production and the first transfer bar was wound in the coil box only one week after the first coil (see Figure 7).
Strip quality was excellent, with 99% of all measured strip thickness and width values within the agreed tolerances, as well as strip profile and flatness as early as after three weeks (see Figures 8 & 9). The crop optimisation system supplied excellent results with short crop ends. Strip thicknesses produced during the first four months of production are shown in Figure 10.

After seven weeks, strip with minimum final thickness of 1.2mm was produced, with gauge, width and final rolling temperature over the whole length of the strip within a narrow tolerance window. The excellent strip coiling profile also demonstrated the high quality of the coilers. Around four months after commissioning, Çolakoğlu Metalurji reduced the final strip gauge to 1.1mm and, despite the large thin-strip volume produced, the amount of strip scrap during this month was only 0.3%.

With the mill pre-optimised and pre-commissioned with the help of Plug & Work and thanks to the excellent co-operation between Çolakoğlu Metalurji and SMS Siemag during all stages of the project, the hot strip mill achieved around one-third of its nominal production during the second month after commissioning. The mill demonstrated its full potential four months after commissioning, when the nominal capacity was exceeded in several production shifts. Figure 11 shows accumulated tonnage produced in the first seven months.

Since the start of production, Çolakoğlu Metalurji has been rolling a large proportion of thin strip; around 20% is less than 2mm, and in more than 90% of all strip produced, the thickness variation is within a range of +/-10µm. The mean thickness variation measured is between 4 and 5µm.

Thanks to the various actuator systems used, the thickness profile is good, with the vast majority of products having a wedge thickness profile of <=10µm. The decisive factor in achieving this excellent result is the use of camber-free rolling, which is based on the interaction of roll alignment control (RAC) and the heavy, position-controlled side guides in the entry and exit section of the rougher.

CONCLUSIONS
The fast commissioning of the mill and the steep run-up curve with excellent strip qualities once again shows that SMS Siemag sees itself as a system provider for mechanical equipment as well as the electrical and automation systems. MS

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